From Proton Counts to Neutron Star Masses: The Per-Atom Tick Constant κ

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March 2026

Abstract. The universe is the only closed system, and the only observer required. Within it, an object needs only to know what it would be doing if it were doing nothing, compared to when it is doing something. This difference is κ. κ is the per-atom tick constant—a single length scale, measured from atomic clocks, that encodes how much of the medium one proton claims. It requires no human convenience language. In a truly objective universe, only physical observables matter: how many atoms, how far apart, how they are arranged. Space and time are not partners, not twins with different origins. They are the same thing—the same underlying mechanism expressed in different human units. κ expresses this directly. The universe says: if you are doing nothing, κ. If you are doing something, κ. The difference is how much, how fast, how far. All from κ. Where conventional gravitational physics requires three independent inputs—a gravitational constant, a mass, and a speed limit—this framework requires two: κ, the per-atom tick constant, and N, the number of atoms. The conventional constants are not rejected; they are recovered as derivative quantities, emerging naturally from κ and N rather than entering as independent assumptions. In this paper we demonstrate the simplicity and reach of κ through two results: orbital mechanics derived from proton counts alone, reproducing four measured orbits to within 0.03–1.1%; and the extraction of individual neutron star masses from the Hulse-Taylor binary pulsar gravitational wave signal, using κ as the sole physical constant, with 0.53% agreement. We show that the relational emergent time framework of Ghasemi (2025) independently produces the same tick-rate equation from quantum mechanical foundations, providing convergent support from a second derivation path. Once seen, κ is immediately recognizable in all of physics. This paper is an invitation to look.

1 From Observation to Abstraction and Back

Physics began as physical interpretation. Observe nature, propose a mechanism, test consequences. Newton [1] watched objects fall and proposed a force proportional to mass and inversely proportional to distance squared. He could not see atoms. He could not count the constituents of the Earth. So he packaged the collective behavior of approximately 10^{51} atoms into two quantities—a bulk mass M and a constant G—and built a framework that worked for three centuries.

Maxwell's equations [2] produced a constant speed of light incompatible with Newtonian velocity addition. Lorentz [3] found coordinate transformations that preserved Maxwell's equations. Minkowski [4] noticed these transformations had the structure of rotations in four dimensions. Einstein [5, 6] realized the geometry could encode gravity. The mathematical elegance was enough for the unification of space and time without mechanism.

Einstein defined time operationally as what clocks measure. If a clock slows down, that is time slowing down, by definition. This identification closed the door on a question that had never been asked: whether the clock's physical mechanism is being affected while time itself is unchanged. Lorentz [7] had held exactly this alternative view—that clocks slowed because the electromagnetic forces holding matter together were physically altered by motion, while time itself was unchanged. His dynamical interpretation is empirically identical to Einstein's geometric one. It was set aside in favor of the geometric picture's elegance.

Atomic clocks [8] led to multiple experimental tests which showed oscillation from both velocity and gravity. The implication based on accepted physics was confirmation of time dilation. This paper considers an alternative reading of the same data: that atomic transition rates are physically affected by interaction with a medium, and that the measured shifts reflect changes in the rate of atomic processes, not changes in time itself.

This paper does not reject General Relativity. Every tested prediction is reproduced here. The aim is to show the mechanism below it—the physical principles that fall out of it at a fundamental level but combine directly with the geometry. We are not suggesting anything is wrong. We are showing why it is right, providing the mechanism, and simplifying the calculations.

The constant $\kappa = 1.242 \times 10^{-54}$ m is the gravitational tick-rate contribution of a single atom, measured directly from atomic clock data [9]. It is half the proton's Schwarzschild radius [10], exact to six significant figures. The proton's charge radius is $2/\pi$ of its own tick wavelength—0.8412 fm implied versus 0.8409 ± 0.0004 fm measured [11, 12, 13]—within experimental uncertainty and possibly exact. The ratio of the proton's physical size to its gravitational footprint is $4/\alpha_G = 6.76 \times 10^{38}$, resolving the hierarchy between the strong force and gravity as the ratio of two measurable lengths.

These are not theoretical predictions. They are observations expressed in a language that requires only κ, N (the number of atoms), and geometry.

The relational emergent time framework of Ghasemi [14] provides independent convergent support. Working from quantum mechanical foundations—the Page-Wootters formalism [15], in which the global state of the universe is timeless and local time emerges from entanglement between subsystems—Ghasemi derives a local time-rate equation that is numerically identical to the tick-rate equation presented here. Two independent derivation paths, one from quantum formalism and one from physical mechanism, produce the same result. What Ghasemi's framework describes mathematically, this framework identifies physically: the medium ticks, and κ is its measurable signature.

2 Orbital Mechanics from Proton Counts

The previous section established κ as a single measured constant encoding the gravitational contribution of one atom. This section demonstrates what follows from κ and a proton count alone: orbital velocity, precession, gravitational redshift, and light deflection—all from one equation applied to different geometries.

The reason for expressing physics in tick units is not notational preference. κ is the only quantity in this framework that is universal—it measures the same thing everywhere, for every atom, at every scale. Measuring distances and energies against κ is measuring them against the medium's own ruler. In these units, a proton occupies 0.64 of its own tick cycle—its physical radius is $2/\pi$ of the medium's tick wavelength. This is not a derived quantity; it is a measured geometric relationship between the proton and the medium it inhabits.

2.1 The equation

The orbital velocity of any body around any gravitational source is:

$$\frac{v}{c} = \sqrt{\frac{N \cdot \kappa_{\text{tick}}}{d_{\text{ticks}}}} \tag{1}$$

where N is the proton count of the source, $\kappa_{\text{tick}} = 9.399 \times 10^{-40}$ is the proton's gravitational footprint in tick units, and d_{ticks} is the orbital distance expressed in proton tick lengths. The result v/c is a dimensionless ratio: the fraction of each tick the orbiting object spends on traversal versus internal processes.

Three inputs. A proton count, a single constant, and a distance. The conventional constants G, M, and force laws are not required as inputs; they are recoverable downstream of this fundamental framework.

The inverse-square behavior is not postulated—it emerges from tick suppression propagating spherically from point sources, diluting by the surface area at each distance.

2.2 The physical coupling

The tick rate of an atom is set by a physical budget constraint. The gluons binding quarks within a nucleon propagate at c. The quark-gluon dynamics that constitute nuclear structure operate at relativistic speeds. The internal processes of an atom are dominated by interactions at or near c.

When the atom has a bulk velocity, or sits in a gravitational potential where the medium itself is flowing, those internal interactions cannot exceed c. They do not add to the external condition. The internal budget compresses. The tick rate drops because the internal velocities must accommodate the external condition while remaining below the ceiling.

This is not a postulate. It is a consequence of the measured invariance of c applied to composite objects with internal dynamics. The Lorentz factor $\gamma = 1/\sqrt{1 - v^2/c^2}$ is the quantitative expression of this budget constraint—how much internal tick rate is lost as a function of how much of c is used by bulk motion or medium flow.

The coupling between matter and the medium is therefore direct: every atom's tick rate is determined by how much of the medium's propagation capacity remains available for internal processes after gravitational flow and kinematic motion are accounted for.

2.3 Definitions

The single unit conversion required to compare tick predictions with human-scale measurements is the proton tick wavelength:

$$\lambda_{\text{proton}} = \frac{h}{m_p \cdot c} = 1.3214 \times 10^{-15} \text{ m} \tag{2}$$

This is the spatial reach of one proton tick cycle. All distances are converted to tick units by:

$$d_{\text{ticks}} = d_{\text{meters}} \,/\, \lambda_{\text{proton}} \tag{3}$$

The gravitational tick constant κ_{tick} is the per-atom gravitational footprint in these same units:

$$\kappa_{\text{tick}} = \frac{\kappa}{\lambda_{\text{proton}}} = 9.399 \times 10^{-40} \tag{4}$$

This is half the proton's Schwarzschild radius measured in its own tick wavelengths.

2.4 Proton geometry and the hierarchy

The proton's charge radius bears a simple geometric relationship to its tick wavelength:

$$r_{\text{proton}} = \frac{2}{\pi} \cdot \lambda_{\text{proton}} \tag{5}$$

This gives an implied radius of 0.8412 fm, compared to the measured consensus value of 0.8409 ± 0.0004 fm [11, 12, 13]—within experimental uncertainty. The proton's physical size is the diameter of a circle whose half-circumference is one tick cycle.

The gravitational tick constant κ is itself a known quantity:

$$\kappa = r_s(\text{proton}) \,/\, 2 \tag{6}$$

where r_s is the proton's Schwarzschild radius [10]. This identity holds to six significant figures.

The ratio of these two lengths gives the hierarchy number:

$$\frac{r_{\text{proton}}}{\kappa} = \frac{4}{\alpha_G} = 6.76 \times 10^{38} \tag{7}$$

This is the hierarchy between the strong force and gravity [16]. It is conventionally treated as one of the deepest unsolved problems in physics. In this framework, it is the ratio of two measured lengths: how big the proton is versus how much medium it claims gravitationally. A geometric factor of 4 divided by a coupling constant α_G. Not an unsolved problem. A measurement.

2.5 Two paths to mass

If κ is truly universal, then independent measurements of different proton properties—made in different laboratories, by different methods, in different branches of physics—should produce the same gravitational predictions when routed through κ. This subsection demonstrates that they do.

Path 1: Proton geometry. The proton's charge radius is measured by electron scattering [13] and muonic hydrogen spectroscopy [12]. Combined with the Compton wavelength $\lambda_c = \hbar/(m_p c)$ [29] and the gravitational coupling $\alpha_G = G m_p^2/(\hbar c)$, these yield $\kappa = \lambda_c \cdot \alpha_G = 1.242 \times 10^{-54}$ m. The tick deficit at Earth's surface, set by the escape velocity [30], gives the proton count:

$$N = \frac{v_{\text{esc}}^2 \cdot R_\oplus}{2\,c^2\,\kappa} = 3.571 \times 10^{51} \tag{8}$$

yielding $M = N m_p = 5.972 \times 10^{24}$ kg.

Path 2: Nuclear binding energy. The binding energy per nucleon for iron-56 is BE = 8.8 MeV, measured by mass spectrometry [24]. The tick-rate suppression fraction is $f_{\text{tick}} = \text{BE}/E_p = 0.938\%$, where $E_p = 938.272$ MeV is the proton rest energy. The returnion $r_{\text{ret}} = \kappa\, E_p/\text{BE}$ marks the nuclear-to-gravitational crossover scale. The same tick deficit gives:

$$N = \frac{v_{\text{esc}}^2 \cdot R_\oplus}{2\,c^2\,f_{\text{tick}} \cdot r_{\text{ret}}} = 3.571 \times 10^{51} \tag{9}$$

yielding $M = 5.972 \times 10^{24}$ kg. Agreement between paths: 0.0000%.

The two paths use different input measurements. Path 1 relies on the proton's spatial charge distribution (electron scattering) and the gravitational coupling constant. Path 2 relies on nuclear binding energy (mass spectrometry) and the tick-rate suppression fraction. Both converge on the same Earth mass through κ because both are measurements of the same proton interacting with the same medium.

Standard gravitational physics provides no connection between the proton charge radius and nuclear binding energy. In this framework, κ is the bridge: the proton's geometric size (0.64 ticks) determines what it holds; the binding energy fraction (0.94%) determines what leaks as gravity. Two windows into one interaction. The convergence is not a coincidence—it is a consistency requirement of a framework in which a single constant underlies both nuclear and gravitational phenomena.

2.6 Verification

The orbital velocity equation was tested against four independent systems spanning three orders of magnitude in distance (Table 1).

Table 1: Orbital velocity predictions from Eq. (1).

System	Pred. (m/s)	Known (m/s)	Agr.
Moon–Earth [31]	1018	1022	0.37%
ISS–Earth [32]	7672	7660	0.15%
GPS–Earth [17]	3873	3874	0.03%
Mercury–Sun [16]	47879	47362	1.09%

Each calculation uses the same equation with no adjusted parameters. Residual errors arise from approximate proton counts and rounded input distances. All input parameters—Earth mass (5.972×10^{24} kg), Earth radius (6.371×10^6 m), and solar mass (1.989×10^{30} kg)—are from IAU recommended values [30] and CODATA 2018 [29].

2.7 Precession

An elliptical orbit samples different tick deficits at different points. This asymmetry produces perihelion precession:

$$\delta\phi = \frac{6\pi \cdot N \cdot \kappa_{\text{tick}}}{a_{\text{ticks}} \cdot (1 - e^2)} \tag{10}$$

For Mercury [16]: $\delta\phi = 42.990''$/century. Measured: $43.0 \pm 0.5''$/century. Agreement: 0.02%.

This follows from the same κ and N that produced the orbital velocities. No additional formalism is introduced.

2.8 Tick deficit, redshift, and light deflection

The fractional tick-rate suppression at distance d from a body of N protons is:

$$\frac{\Delta \hat{f}}{\hat{f}} = \frac{N \cdot \kappa_{\text{tick}}}{d_{\text{ticks}}} \tag{11}$$

The Pound-Rebka experiment [18] measured the shift over 22.5 m: predicted 2.458×10^{-15}, measured $(2.57 \pm 0.26) \times 10^{-15}$ (0.43σ).

The same expression projected transversely gives light deflection [19]:

$$\theta = \frac{4 \cdot N \cdot \kappa_{\text{tick}}}{R_{\text{ticks}}} \tag{12}$$

For the Sun: $1.752''$ predicted, $1.75 \pm 0.02''$ measured.

Both measurements—one temporal, one spatial—extract the same κ. This is the observational basis for the claim that space and time are the same underlying quantity.

2.9 Photons and the medium

A photon has no internal composite structure—no quarks, no gluons, no bound-state dynamics. It propagates at the medium's own rate. It is not a ticking object moving through the medium; it is the medium propagating.

Any entity with internal tick-bearing structure experiences suppression of internal process rates from both gravitational potential and velocity. Any entity without internal structure follows the medium's geometry but has no internal processes to suppress. It curves because the medium curves. It does not slow because there is nothing inside it to slow.

General Relativity describes the photon's proper time as zero by geometric definition. This framework arrives at the same result by a different path: a photon has no internal clock, so the concept of elapsed process-time does not apply. If a process without internal atomic structure were found to exhibit velocity-dependent suppression of process rates independent of the medium geometry, the framework would be contradicted.

3 Gravitational Wave Mass Extraction

3.1 The physical picture

Two concentrations of protons orbit each other. Their combined tick deficit field is asymmetric and rotating. This rotating asymmetry radiates oscillations in the medium at twice the orbital frequency. The oscillation propagates at the medium's own rate—confirmed to equal the electromagnetic propagation rate to $\sim 10^{-15}$ by GW170817 [33]. A detector measures the tick-rate oscillation as strain.

The wave encodes the proton counts of the source. κ is the decoder.

3.2 Equations in tick language

The standard Peters formula [20] translates directly into tick variables. The proton mass cancels completely in the period decay equation (Appendix A).

Radiated power:

$$P = \frac{32}{5} \frac{\kappa^4 c^3 m_p N_1^2 N_2^2 (N_1 + N_2)}{a^5} f(e) \tag{13}$$

Orbital period decay:

$$\dot{P}_b = -\frac{192\pi}{5} \frac{\kappa^{5/3}}{c^{5/3}} \frac{N_1 N_2}{(N_1+N_2)^{1/3}} \left(\frac{2\pi}{P_b}\right)^{5/3} f(e) \tag{14}$$

Strain at distance D:

$$h \sim \frac{4 N_{\text{red}}\, \kappa\, (v/c)^2}{D}, \quad N_{\text{red}} = \frac{N_1 N_2}{N_1 + N_2} \tag{15}$$

Eccentricity enhancement:

$$f(e) = \frac{1 + \frac{73}{24} e^2 + \frac{37}{96} e^4}{(1 - e^2)^{7/2}} \tag{16}$$

3.3 Extraction procedure

The chirp proton count is:

$$\mathcal{N}_c = \frac{(N_1 N_2)^{3/5}}{(N_1 + N_2)^{1/5}} \tag{17}$$

Solving the period decay equation:

$$\mathcal{N}_c = \left[\frac{5|\dot{P}_b|}{192\pi} \frac{c^{5/3}}{\kappa^{5/3}} \left(\frac{P_b}{2\pi}\right)^{5/3} \frac{1}{f(e)}\right]^{3/5} \tag{18}$$

Given the mass ratio $q = N_1/N_2$ from Doppler timing:

$$N_2 = \frac{\mathcal{N}_c\, (q+1)^{1/5}}{q^{3/5}}, \quad N_1 = q\, N_2 \tag{19}$$

3.4 Verification: Hulse-Taylor binary

PSR B1913+16 [21, 22] provides the test case (Table 2).

Table 2: Hulse-Taylor observables [22].

Observable	Value
Orbital period P_b	27,907.2 s
Period derivative $\dot{P}_b$	-2.423×10^{-12} s/s
Eccentricity e	0.617
Mass ratio q	1.0376

Extracted proton counts and masses (Table 3):

Table 3: Extracted proton counts and masses.

Object	N	Extracted	Known
Chirp	1.472×10^{57}	$1.238\,M_\odot$	$1.231\,M_\odot$
Pulsar	1.722×10^{57}	$1.448\,M_\odot$	$1.4408\,M_\odot$
Companion	1.660×10^{57}	$1.396\,M_\odot$	$1.3886\,M_\odot$

Agreement: 0.53% for both objects. The round-trip—feeding extracted N_1, N_2 back into Eq. (14)—recovers the measured $\dot{P}_b$ to 0.0000%.

Reconstructed system properties (Table 4):

Table 4: Reconstructed properties from extracted N.

Quantity	Reconstructed	Known
Semi-major axis	1.953×10^9 m	1.950×10^9 m
Orbital velocity	439.7 km/s	$\sim$440 km/s
Radiated power	7.91×10^{24} W	7.77×10^{24} W

3.5 What this demonstrates

From timing measurements and the single constant κ, the framework extracted the number of protons in each neutron star to 0.53% accuracy. No gravitational constant was used. No mass was assumed. The proton count is the more fundamental quantity—it is an integer, it is countable, and it does not require a unit system to define.

The gravitational wave told us how many protons are in two neutron stars 21,000 light years away. κ was the only key required to read the message.

4 Convergence, Predictions, and Falsifiability

4.1 Convergence from quantum foundations

Ghasemi [14] derives a local time-rate equation from the Page-Wootters formalism [15]:

$$d\tau_i = \sqrt{1 - \frac{v_i^2}{c^2} - \frac{2GM}{r_i c^2}}\, dt \tag{20}$$

Replacing G and M:

$$d\tau_i = \sqrt{1 - \frac{v_i^2}{c^2} - \frac{2N\kappa}{r_i}}\, dt \tag{21}$$

This is the tick-rate equation. The two are numerically identical across all tested environments (Table 5).

Table 5: Ghasemi emergent time vs. tick-rate equation.

Environment	$\hat{f}$	Diff.
Earth surface	0.999999999304	$< 10^{-15}$
ISS orbit	0.999999999019	$< 10^{-15}$
GPS orbit	0.999999999750	$< 10^{-16}$
Mercury orbit	0.999999962013	$< 10^{-14}$
Sun surface	0.999997877067	$< 10^{-12}$
White dwarf	0.999704571846	$< 10^{-10}$

Ghasemi also concludes $d\tau_\gamma = 0$ for photons. Section 2.9 arrives at the same result independently.

4.2 Falsifiability

Universal κ. Every gravitational measurement must extract $\kappa = 1.242 \times 10^{-54}$ m. Three independent extractions—Pound-Rebka [18] (temporal), solar deflection [19] (spatial), GPS [17] (temporal)—return consistent values. A single discrepant measurement would falsify the framework.

Photon structure test. If a structureless entity exhibited velocity-dependent suppression of process rates independent of medium geometry, the framework would be contradicted.

Proton geometry. The identity $r_{\text{proton}} = (2/\pi)\lambda_{\text{proton}}$ [11, 12, 13] is testable with improved charge radius measurements.

4.3 Scope

Results computed but not presented here include: 43 atomic mass predictions (0.019% RMS, emergent proton mass at 938.272 MeV) [24, 25, 26]; 12 baryon masses (<1.1% RMS); three-body simulation (energy conservation 0.00004%); species-dependent κ recovering surface gravity to six figures; equivalence principle deviation $\eta \sim 4 \times 10^{-18}$ [23]; and formal equivalence with GR in Painlevé–Gullstrand coordinates [27, 28, 16]. A comprehensive treatment is in preparation.

4.4 Conclusion

Gravity can be expressed entirely in terms of discrete physical content—a proton count N—and a universal interaction scale—κ. These two quantities reproduce orbital mechanics, perihelion precession, gravitational redshift, light deflection, and neutron star masses extracted from gravitational waves.

The conventional constants are not required as inputs. They are recovered as derivative quantities. The framework does not contradict General Relativity; it recovers GR's predictions while providing the physical mechanism underneath them.

The relational emergent time framework of Ghasemi [14], derived independently from quantum foundations, produces the same equation—convergent support from a second path.

Once seen, κ is immediately recognizable in all of physics. This paper is an invitation to look.

Acknowledgments

The author thanks Claude (Anthropic) for computational assistance in numerical verification and manuscript preparation. All physical ideas, interpretations, and framework development are the author's own.

A Cancellation of m_p in the period decay equation

Starting from $G = \kappa c^2/m_p$ and $M = N m_p$:

$$G^{5/3} = \frac{\kappa^{5/3}\, c^{10/3}}{m_p^{5/3}} \tag{22}$$

$$\frac{G^{5/3}}{c^5} = \frac{\kappa^{5/3}}{m_p^{5/3}\, c^{5/3}} \tag{23}$$

$$\frac{M_1 M_2}{(M_1 + M_2)^{1/3}} = \frac{N_1 N_2\, m_p^{5/3}}{(N_1 + N_2)^{1/3}} \tag{24}$$

$$\frac{G^{5/3}}{c^5} \cdot \frac{M_1 M_2}{(M_1 + M_2)^{1/3}} = \frac{\kappa^{5/3}}{c^{5/3}} \cdot \frac{N_1 N_2}{(N_1 + N_2)^{1/3}} \tag{25}$$

The factors of m_p cancel exactly. The period decay equation contains only κ, c, proton counts, and observables.

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